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MID-WINTER INSTALLATION OF PROTECTED MEMBRANE ROOFS IN ALASKA,(U)

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Mid-winter installation of protected membrane roofs in Alaska

Cover: Workers are clearing the snow-covered roof in preparation for installing the membrane. (Photography by R. Demars, CRREL.)

CRREL Report 77-21

Mid-winter installation of protected membrane roofs in Alaska

Haldor W.C. Aamot

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Cold weather limits the successful application of built-up roofing, but often a roof installation must be completed late in the fall or in the winter. The loose-laid protected membrane roof with a synthetic sheet membrane can be installed in the middle of the winter with complete reliability. A synthetic membrane is traditionally more expensive than built-up roofing (rising crude oil prices, however, have reversed this condition), but it has two special features besides its suitability for winter installation: it can be placed on a damp deck, if necessary, and, being loose-laid, it does not split because of deck movement. This report documents information on the installation of two roofs in Anchorage, Alaska, during January and February 1972, including a discussion of the necessary snow removal from the bare deck and the use of portable shelters for preparing the lap joints between sheets during very cold NEXT

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weather. The winter installation caused no special construction problems and the advantages of the synthetic membrane make it an attractive alternative to built-up roofing. The cost of loose-laid protected membrane roofs in Alaska was, in 1972, nearly $300 per square ($28/m^2), including insulation. Prices are rising as labor costs rise and as more insulation is specified.

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PREFACE

This report was prepared by Dr. Haldor W.C. Aamot, Research Mechanical Engineer, Construction Engineering Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory.

The study covered by the report was performed under DA Project 4A162121A 894, *Engineering in Cold Environments*; Task 21, *Cold Regions Building Systems for Military Installations*; Work Unit 001, *Roofs of Military Structures in Cold Regions.*

Technical review of this report was conducted by D. Schaefer, formerly Research Civil Engineer of the Alaskan Projects Office of CRREL; and W.C. Cullen, and R.G. Mathey of the National Bureau of Standards.

The cooperation of the staff of the University of Alaska in providing access to their buildings during the construction of the roofs and cost information on the applicable contracts is gratefully acknowledged.

Special recognition is given to D. Schaefer for photographic coverage of the construction and for completion of cost information.

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Haldor W.C. Aamot

INTRODUCTION

The reliable installation of a built-up roof membrane requires skillful workmanship and favorable weather conditions. But sometimes the construction schedule of a building requires roofing work in the fall or winter when conditions are not at all favorable. In the northern states, particularly in Alaska, cold weather arrives early in the fall and methods of cold weather construction are greatly needed.

Are there ways to install a built-up roof membrane at below-freezing temperatures with full assurance of the desired quality? It does not appear that a practical solution can be offered. The asphalt chills too quickly on the cold deck and the felts are stiff and brittle. Specifications limit the installation of built-up roofing to ambient temperatures above 40°F (5°C). But it is possible to install a different roof during cold weather with no sacrifice in quality and durability: the loose-laid protected membrane roof using a one-ply synthetic sheet membrane instead of asphalt and felts. This alternative offers new opportunities to the contractor, the building owner and the architect.

This report documents observations made of the installation of two protected membrane roofs with synthetic sheet membranes in Anchorage during the winter 1971/72. It describes the design of the roof, the steps taken during the construction, the work time required, and the cost of the roof.

THE PROTECTED MEMBRANE ROOF

The protected membrane roof differs from the conventional flat roof in one small but fundamental way: the waterproof membrane is *under* the insulation instead of *on top* of it and is thus protected from direct exposure to extreme temperatures, sunlight and foot traffic, which are all factors that accelerate its aging and loss of waterproof quality. Figure 1 illustrates the difference between the two principles.

The water flows over the concrete pavers, penetrates through the open butt joints between them and between the insulation boards, and finally flows to the drains on the membrane in little channels formed by the chamfered bottom edges of the boards.

The materials used for the construction of the protected membrane roof are similar to those of the conventional roof. The main difference is in the sequence of their installation. If built-up roofing is used for the membrane, it is installed on the deck just as is done for a conventional roof. If a sheet rubber membrane is used, it is loosely laid on the deck. The sheets are delivered by the manufacturer in prepared sizes according to a layout plan. Sheet sizes may be several thousand square feet so that only few field splices are needed. The sheets are laid out smoothly to avoid wrinkles and creases and with appropriate overlap for splicing. Splices between sheets, penetrations and flashings are made in accordance with the membrane manufacturer's specifications. The membrane material is either isobutylene-isoprene (Butyl) or ethylene propylene diene monomer (EPDM) rubber. Other synthetic membranes such as those made of polyvinyl chloride (PVC) or polyisobutylene (PIB) are also becoming available. EPDM should be used for flashings and penetrations because of its greater service temperature range. Both rubbers have high resistance to aging compared with other rubbers or bitumen.

The insulation must be water and freeze-thaw resistant. Extruded, closed-cell polystyrene foam boards meet this requirement. Their bottom edges should be chamfered [½ to ¾ in. (12 to 18 mm)] to improve drainage. The concrete pavers serve as ballast against flotation and wind uplift and also as protection from foot traffic and hail. However, they do not need to produce a waterproof seal; on the contrary, the open butt joints between them permit the roof to dry after a rain. The ballast weight required to prevent flotation is about 15 lb/ft^2 (75 kg/m^2) on 2 in. (50 mm) of

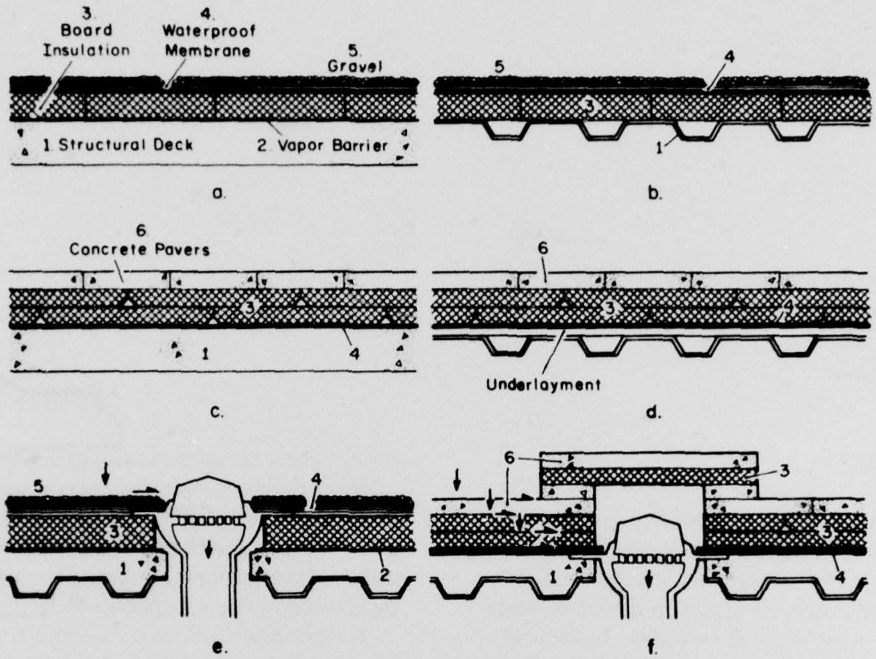

Figure 1. A conventional built-up roof (a, b) is compared with a protected membrane roof (c, d). The membrane, covered with insulation, stays at a temperature close to the indoor temperature. The concrete pavers are shield and ballast for the insulation. Their temperature fluctuates greatly between day and night, summer and winter. They merely shed rain, which percolates to the membrane and flows to the drain (e, f). Meltwater from the snow cover also flows because the membrane is warm. The interior drains are covered for frost protection to ensure meltwater drainage. The protected membrane serves simultaneously as a vapor barrier and eliminates the possibility of trapping moisture in the insulation, as in the conventional roof. Different types of decks are shown for comparison. The metal deck (b) is a good vapor barrier if the joints are tight. Wood, plaster or mineral boards, adhered to the fluted metal deck, are needed to form a smooth surface for the protected membrane in case d.

insulation. Coarse washed and sized gravel [1-in. (25-mm) size] is used frequently for minimum initial cost but maintenance and repair costs are greater than with concrete pavers or flat, cut stones. Pavers also produce a roof terrace suitable for functional purposes. In fact, they produce a roof terrace suitable for recreational or other purposes.

The deck should have a slight positive slope for reliable drainage and the drains should be on the interior of the building with an insulating cover to prevent icing. During the winter the snow cover provides added insulation. Meltwater can drain readily because the membrane is warm.

WINTER CONSTRUCTION CONSIDERATIONS

When in the protected membrane roof the insulation is adhered to the built-up roof membrane, the need for ballast is reduced. However, adhesion adds cost to the installation work and to subsequent maintenance and repair work. The need for ballast is reduced accordingly. This is important where structural weight is critical.

In the loose-laid design, the insulation is not adhered. It can always be lifted for inspection or replacement. The sheet rubber membrane is also loose-laid with attachments only at the perimeter and at penetrations. Contrary to the built-up roof membrane, the loose-laid sheet rubber membrane is unaffected by deck movement; therefore, the chance of splitting is eliminated.

A further advantage of the loose-laid rubber membrane is the possibility of laying it on a damp deck, since, often, a dry deck simply cannot be provided. The deck may be a new gypsum deck that takes days to dry or any other deck on which there has been rain or snow. The need to wait for the deck to dry is eliminated.

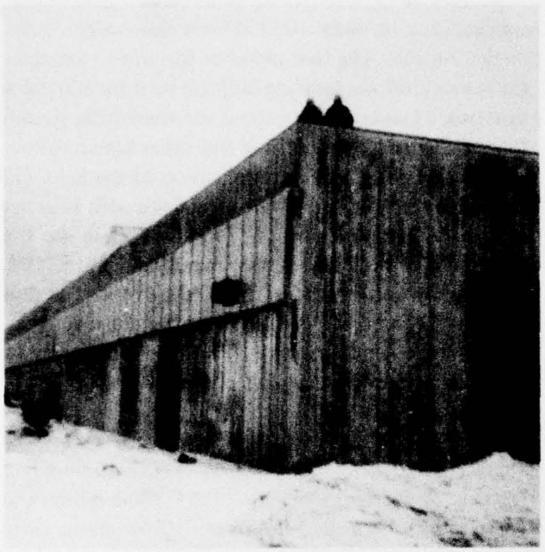

Figure 2. Library building of the University of Alaska in Anchorage.

Figure 3. Metal deck, underlayment and sheet rubber membrane during roof installation.

Figure 4. Lap joint between rubber sheets in preparation.

Figure 5. Installed membrane with completed joints.

Figure 6. The A-frame shelter is placed over a lap joint to be made.

The main advantage of the loose-laid rubber membrane is the opportunity for cold weather installation. Butyl is flexible to –40°F (–40°C) and EPDM to –75°F (–57°C). Flashings and sheet splices can be made under portable shelters that are heated with portable space heaters. With this system the roofer's season is extended through the whole winter.

In January and February of 1972, two roofs of this type were completed in Anchorage, Alaska, for the Community College Extension of the University of Alaska. One is on the Library building, the other on "K" building (general classrooms and offices). The temperature was about 0°F (–18°C) during the membrane installation. A-frame shelters were placed over the splices and heated with portable air heaters. The temperature was about 32°F (0°C) for the splicing work.

A view of the Library building, showing snow on the ground, is given in Figure 2. Figure 3 shows the metal deck in the foreground and the rigid fiberboard underlayment; the rest of the roof is covered with the rubber membrane. In the left foreground, the corner of a piece of rubber sheet is displayed. Figure 4 shows an open lap joint between sheets in preparation. Figure 5 shows a large roof area with the membrane installation completed. Figure 6 shows the portable A-frame shelter on the roof; photograph on cover of report shows workers preparing a lap joint under the shelter.

CONSTRUCTION COSTS

In July 1971, a loose-laid protected membrane roof was installed on Bldg. 1053 at Fort Wainwright, Fairbanks, Alaska. The first phase of the work included the removal of the existing built-up roof membrane and fiberboard insulation to expose the steel deck, modification of the perimeter curbing and other preparation. The second phase was the application of the ½-in. (13-mm) plywood decking to the steel deck with adhesive to provide a smooth surface. The third phase was the placement of the Butyl rubber membrane and EPDM flashing and adjustment of the height of the roof drains. The fourth phase was the placement of the insulation boards and concrete pavers. The time requirements for labor and supervision for the 10,900-ft² (1008-m²) roof were:

Phase 1: removal and preparation	1.35 man-hours/square
Phase 2: plywood decking	1.29 man-hours/square
Phase 3: membrane and flashings	1.48 man-hours/square
Phase 4: insulation and pavers	3.13 man-hours/square
Total work:	7.25 man-hours/square

The cost of the construction was \$279/square (\$26/m²).

In new construction, phase 1 is not necessary and the total time requirement would be about 6 man-hours/square (0.65 m-h/m²) in the example. On a smooth deck, phase 2 can also be eliminated. The time requirement for the installation of the rubber membrane, insulation and concrete pavers would then be less than 5 man-hours/square. This information was compiled by Schaefer (1971).*

The Library roof built in January 1972 in Anchorage included the installation of rigid fiberboard underlayment on the steel deck, a Butyl rubber membrane, insulation boards and concrete pavers. The time required for labor and supervision was about 4.5 man-hours/square and the price was \$290 per square, (\$27/m²), including the bid price for snow removal.

The cost of the materials was about \$45 for the Butyl or EPDM rubber, \$45 for the insulation (3 in. thick) and \$45 for the concrete pavers, all per square (9.3 m²).

A comparison of the cost of the sheet rubber membrane with that of builtup roofing may be attempted using the preceding figures. With an installation time for the sheet rubber membrane of 1.5 man-hours/square at \$10/man-hour, the cost is \$15 for labor and supervision and \$45 for materials, for a total of \$60/square

* Schaefer, D. (1971) Installation of loose-laid inverted roof system at Ft. Wainwright, Alaska. USA CRREL Technical Note (unpublished).

(6.50/m^2). However, every roofing contractor, and every architect, estimates his own cost of built-up roofing. The figure may have been about half that for the sheet rubber membrane in 1972 (but higher today because of increased oil and bitumen prices). However, the installation time for the sheet rubber is less than for the built-up roofing. This difference becomes important with high wage rates.

The initial cost of protected membrane roofs is generally higher than that of conventional built-up roofs, but the life-cycle cost of the protected membrane roofs is generally lower. The university's figures show that changing a structural concrete deck from a live-load rating of 40 lb/ft^2 to 100 lb/ft^2 costs about $10/square. The university estimates the price differential between protected membrane roofs and conventional roofs at about $75/square (Holden 1974).*

CONCLUSION

The loose-laid protected membrane roof using sheet rubber has the special feature that it can be installed in the middle of the winter. Its other advantages are that it is free from splits caused by deck movement, and that it can be installed on a damp deck, and in a short time.

The sheet rubber membrane is traditionally more expensive than the one made of built-up roofing, although the price trends have reversed this condition. In certain situations, however, its characteristics make it the required choice. For instance, during the winter it may be the only permanent membrane that can be installed reliably. In addition, to the architect it offers new design opportunities, and to the roofing contractor it offers a new method for a growing market.

* Holden, R. (1974) Personal communications. Office of Planning and Institutional Studies, University of Alaska.

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